Effect of a School-Based Water Intervention on Child Body Mass Index and Obesity

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IMPORTANCE Decreasing the amount of caloric beverages consumed and simultaneously increasing water consumption is important to promoting child health and decreasing the prevalence of childhood obesity.

OBJECTIVE To estimate the impact of water jets (electrically cooled, large clear jugs with a push lever for fast dispensing) on standardized body mass index, overweight, and obesity in elementary school and middle school students. Milk purchases were explored as a potential mechanism for weight outcomes.

DESIGN, SETTING, AND PARTICIPANTS This quasi-experimental study used a school-level database of cafeteria equipment deliveries between the 2008-2009 and 2012-2013 and included a sample of 1227 New York, New York, public elementary schools and middle schools and the 1,065,562 students within those schools.

INTERVENTION Installation of water jets in schools.

MAIN OUTCOMES AND MEASURES Individual body mass index (BMI) was calculated for all students in the sample using annual student-level height and weight measurements collected as part of New York’s FITNESSGRAM initiative. Age- and sex-specific growth charts produced by the Centers for Disease Control and Prevention were used to categorize students as overweight and obese. The hypothesis that water jets would be associated with decreased standardized BMI, overweight, and obesity was tested using a difference-in-difference strategy, comparing outcomes for treated and nontreated students before and after the introduction of a water jet.

RESULTS This study included 1,065,562 students within New York City public elementary schools and middle schools. There was a significant effect of water jets on standardized BMI, such that the adoption of water jets was associated with a 0.025 (95% CI, −0.038 to −0.011) reduction of standardized BMI for boys and a 0.022 (95% CI, −0.035 to −0.008) reduction of standardized BMI for girls (P < .01). There was also a significant effect on being overweight. Water jets were associated with a 0.9 percentage point reduction (95% CI, 0.015 to 0.003) in the likelihood of being overweight for boys and a 0.6 percentage reduction (95% CI, 0.011 to 0.000) in the likelihood of being overweight for girls (P < .05). We also found a 12.3 decrease (95% CI, −19.371 to −5.204) in the number of all types of milk half-pints purchased per student per year (P < .01).

CONCLUSIONS AND RELEVANCE Results from this study show an association between a relatively low-cost water availability intervention and decreased student weight. Milk purchases were explored as a potential mechanism. Additional research is needed to examine potential mechanisms for decreased student weight, including reduced milk taking, as well as assessing impacts on longer-term outcomes.
Water is essential for human function, prevents dehydration, and is critical to a nutritious diet. Water is also a healthy alternative to caloric beverages, particularly sugar-sweetened beverages (SSBs), which have been linked to childhood obesity. Previous work suggests that replacing SSBs with calorie-free beverages may lead to decreased weight gain in children.

Nationally, obesity rates in children are high. In 2012, more than one-third of children and adolescents were classified as overweight or obese. In New York, New York, the obesity rate of children in kindergarten through eighth grade was 20.7%. Childhood obesity has both immediate and long-term effects on health. Since 2001, New York has implemented policies and initiatives to improve the school food environment, including improving nutrition standards, expanding fruit and vegetable offerings, removing soda from vending machines, and replacing whole milk with low-fat milk. More specifically, one effort to reduce SSBs in New York schools was a policy established in the Chancellor’s Regulations prohibiting artificial flavors, colors, or sweeteners in all beverage vending machines and limiting beverages to less than 10 cal per 8 oz for elementary schools and middle schools (less than 25 cal per 8 fl oz for high schools). All schools made this change before the 2009-2010 academic year. These initiatives are part of a large, multifaceted effort to curb childhood obesity and promote student wellness. Policies or programs to encourage children to drink water can also play an important role in addressing childhood obesity.

In 2009, New York’s Department of Health and Mental Hygiene and Department of Education (NYCDOE) launched an intervention to increase access to drinking water at lunchtime by placing “water jets” in school cafeterias. Water jets are electrically cooled, large, clear jugs with a push lever for fast dispensing that give students access to clean New York tap water. Water jet machines both chill the water and oxygenate it to keep it tasting fresh and cost approximately $1000 per machine. Plastic disposable cups are also provided by schools for use with the water jet machines. The water jet intervention allows children to choose water as a calorie-free beverage during meal times with the goal that by offering water at lunch at school, children will both consume more water and learn to think of water when they are thirsty, reducing the amount of calories consumed through other beverages. The ultimate goal is to introduce water jets to all schools over the next several years. Interviews with district- and school-level personnel suggest the specific timing of water jet adoption by a school reflects the interaction of opportunity, convenience, and happenstance, rather than systematic targeting.

Previous studies found providing water to students in schools may be beneficial. One study on water jets in New York examined water taking before and after water jet installation in 9 schools and compared them with control schools. The study found that students whose schools installed water jets nearly tripled their water taking at lunchtime relative to control schools. Milk taking was also observed, and decreases in consumption were seen in the short term.

Building on previous work, the aim of our study was to examine the effect of the water jets initiative in New York on student body mass index (BMI), overweight, and obesity. Milk purchases were explored as a potential mechanism for weight outcomes. This work adds to the literature on school-based water interventions and informs future efforts to curb childhood obesity.

At a Glance
- The goal of this study was to estimate the impact of a relatively low-cost school-based water availability intervention, water jets, on standardized body mass index (BMI), overweight, and obesity in elementary school and middle school students.
- Results indicated a statistically significant decrease in standardized BMI, likelihood of being overweight, and likelihood of obesity for boys and a significant decrease in standardized BMI and likelihood of being overweight for girls.
- There was also a decrease in the amount of milk bought by students, which was explored as a potential mechanism of weight reduction.
- Results from this study show an association between a relatively low-cost water availability intervention and decreased student weight.

Methods
Sample
The sample consisted of 1227 New York public elementary schools and middle schools and the 1065 562 students within those schools (3,319,083 observations). We excluded charter and special education schools from our sample. We also excluded schools (in a given year) where less than 50% of students participated in the New York FITNESSGRAM (NYCDOE only 1.6% of kindergarten through eighth-grade student observations and students with missing New York FITNESSGRAM data (4.1% of students in schools not dropped owing to low New York FITNESSGRAM coverage). Using a school-level database of cafeteria equipment deliveries between the 2008-2009 and 2012-2013 academic years provided by the NYCDOE Office of School Food, we determined if and when a school received a water jet. Of 1227 schools, 483 received a water jet (39.3%) and 744 did not (60.7%).

Study procedures were approved by both New York University and NYCDOE institutional review boards. No individual consent was required for this analysis of deidentified administrative data.

Measures, Research Design, and Statistical Analysis
BMI (Standardized BMI)
Individual BMI was calculated for all students in our sample as weight in kilograms divided by height in meters squared. New York schools have conducted the New York FITNESSGRAM annually for all students in kindergarten through 12th grade since the 2005-2006 academic year as part of the standards-based physical education program. Physical education teachers, trained on measurement protocols as part of the New York FITNESSGRAM initiative, collected data on height and weight. Physical education teachers’ measures of student height and weight for school-based BMI screenings have previously been
found reliable. Body mass index was calculated using the standard formula (weight/height)^2×703. We standardized BMI (zBMI) by school year administered, age, and sex. A small number of children (<0.1%) with biologically implausible values of BMI, defined by the Centers for Disease Control and Prevention as more than 5 SDs away from the mean, were excluded from our analysis.21

Overweight
We used age- and sex-specific growth charts produced by the Centers for Disease Control and Prevention to categorize students as overweight (≥85th BMI percentile).21

Obese
We used age- and sex-specific growth charts produced by the Centers for Disease Control and Prevention to categorize students as obese (≥95th BMI percentile).21 Students classified as obese are a subset of those classified as overweight.

Demographics
Baseline demographic variables were collected from a richly detailed administrative data set for all students in New York public schools between the 2007-2008 and 2012-2013 academic years. Variables included the number of students enrolled in each school and percentages of students eligible for free or reduced-price meals, learning English as a second language, enrolled in special education, female, foreign born, Hispanic, white, black, and Asian.

Milk Purchases
We obtained data on milk purchases between the 2010-2011 and 2012-2013 academic years from the NYCDOE Office of School Food, including annual milk purchases per cafeteria/kitchen, total and by type (low-fat [1%] white, skim white, fat-free chocolate, and whole). Very few schools (6.6% by 2013) purchased whole milk after NYCDOE acted to eliminate whole milk from school cafeterias during the 2005-2006 academic year.22 Those few schools that offered whole milk are predominately schools serving special education students. Because milk purchases are recorded by kitchen, it is impossible to separately identify purchases for schools sharing kitchens. In 2013, for example, 42.5% of kitchens serving elementary schools and middle schools provided meals for more than 1 school. Thus, we limited our analysis of milk purchases to elementary schools and middle schools not sharing kitchen facilities.

Research Design
To examine the effect of water jets on student BMI, overweight, and obesity, we used a difference-in-difference strategy, comparing outcomes for treated and nontreated students before and after exposure, exploiting the staggered introduction of water jets. We identified a student as being “treated” by a water jet if he or she spent 60 or more cumulative school days in a school with a water jet. These estimates should be interpreted as “intent to treat” because we did not identify whether or how much an individual student used the water jet.

To estimate the effect of water jets on milk purchases, we again used a difference-in-difference strategy to identify changes in milk purchases between schools that had a water jet and schools that did not have a water jet, before and after introduction of a water jet. We defined water jet schools as those having a water jet for 3 or more months, roughly 60 school days. We examined 3 separate outcomes: total milk, chocolate milk, and low-fat and skim white milk. Total milk included all milk types, including whole milk. Chocolate milk served in New York schools is fat-free, and was estimated separately because it is sweetened and flavored. Low-fat and skim white milk were estimated together.

Statistical Analysis
School-level characteristics for water jet schools vs non–water jet schools were compared using t tests. To estimate the effect of water jets on zBMI, we first used an ordinary least squares model controlling for student characteristics and school (school fixed effects). We used a second ordinary least squares model with student fixed effects to control for individual student changes in each year. The same set of models was used to estimate the effect of water jets on overweight and obesity, again using a linear probability model with school fixed effects and then with student fixed effects. We estimated all models separately by sex. We presented the main effect of introducing a water jet over and above any change over time for schools that did not introduce the water jet.

To estimate the effect of water jets on milk purchases per student, we used an ordinary least squares model with 3 separate specifications. The first model included year fixed effects, the second adds school fixed effects, and the third adds time-varying school characteristics (share of students by race, sex, eligibility for free and reduced lunch, special education status, English language–learner status, and total enrollment). While ordinary least squares models provided a linear approximation to the average marginal effects, we also estimated logistic regression models with similar results (not shown). Analyses were conducted with Stata 12 statistical software (StataCorp), and standard errors were clustered at the school level.

Results
Prevalence of Water Jets
By policy design, water jets in New York increased over time during our analysis period, and machines were often placed in schools in waves (Figure). The water jet intervention began with a pilot of 5 school cafeterias in the 2008-2009 academic year. By the 2012-2013 academic year, roughly two-thirds of NYCDOE elementary schools and middle schools had a water jet machine installed in the cafeteria.

Descriptive Statistics
Descriptive statistics for the baseline year (2007-2008) are provided in Table 1. Overall, schools with water jets (n = 374) were not systematically different than those without (n = 482) on baseline characteristics. In the 2007-2008 academic year, water jet schools had similar percentages of overweight students (38.9% vs 39.2%) and obese students (21.1% vs 21.4%) than non–water jet schools. However, water jet schools did have...
different percentages of Asian, special education, and foreign-born students than non–water jets schools (P < .05). Differences were small in magnitude.

**Estimating the Impact of Water Jets**

**Standardized BMI**

Table 2 shows the effect of water jets on our 3 outcomes of interest. There was a significant main effect of water jets on zBMI, such that the adoption of water jets was associated with a 0.025 (95% CI, −0.038 to −0.011) reduction of zBMI for boys and a 0.022 (95% CI, −0.035 to −0.008) reduction for girls (P < .01) in the specification with school fixed effects. In the specification with student fixed effects, there was a significant main effect on zBMI for boys but not for girls. The adoption of water jets was associated with a 0.017 (95% CI, 0.034–0.001) reduction of zBMI for boys (P = .04).

**Overweight**

There was also a significant main effect of water jets on overweight, such that the adoption of water jets was associated with a 0.9 percentage point reduction (95% CI, −0.015 to −0.003) in the likelihood of being overweight for boys (P < .01) and 0.6 percentage point reduction (95% CI, −0.011 to 0.000) for girls (P < .05) in the specification with school fixed effects. In the specification with student fixed effects, there was a 1.2 percentage point reduction (95% CI, −0.019 to −0.005) in the likelihood of being overweight for boys (P < .01) and 0.6 percentage point reduction (95% CI, −0.013 to −0.001) for girls (P < .1).

**Obese**

There was a significant main effect of water jets on obesity for males (β = −0.005; 95% CI, −0.010 to −0.001; P = .02) in our school fixed-effects model that did not reach statistical significance in our student fixed-effects models (β = −0.005; 95% CI, −0.010 to −0.001; P = .08). There was a negative but not significant main effect of water jets on obesity for girls (β = −0.003; 95% CI, −0.007 to 0.001; P = .15 in the school fixed-effects model and β = −0.002; 95% CI, −0.007 to 0.001; P = .55 in the student fixed-effects model).

**Milk Purchases**

Table 3 displays results of the school-level analysis that examines the effect of water jets on milk purchases from the 2010-2011 to 2012-2013 academic years in schools that had a water jet for 3 or more months, corresponding to roughly 60 school days. There was a 12.3 decrease (95% CI, −19.371 to −5.204) in the number of half-pints of all milk types purchased per student per year (P < .01). Estimating separately by milk type revealed a significant effect of water jets on fat-free chocolate milk purchases, but not on low-fat and skim white milk purchases. We found a 13.6 decrease (95% CI, −19.796 to −7.435) in fat-free chocolate milk half-pints purchased per student per year (P < .01) and a 1.4 decrease (95% CI, −4.437 to 7.186) in low-fat and skim white milk purchased per student per year, albeit insignificant (P = .64). Adding school characteristics yielded similar results. (Schools did not differentially change the availability of chocolate milk after introducing the water jet; results not shown.) Adding school fixed effects yielded similar coefficients. Results are robust to expanding our water jet treatment group to include schools with shorter experiences with water jets. For example, expanding the water jet treatment group (schools with water jets for 3 months or more) to include schools with water jets for 2 to 3 months (roughly 40-60 school days) yields similar results.

**Discussion**

The goal of this study was to estimate the impact of water jets on zBMI, overweight, and obesity in elementary school and middle school students. Analyses revealed that zBMI and overweight decreased significantly for boys, and zBMI and overweight also decreased significantly for girls. Results attenuated with student fixed effects. Including student fixed effects means the effects were estimated using comparisons across the same student over time (rather than comparing the same
This is a conservative estimation strategy, eliminating the possibility that results were driven by changes in student characteristics or other unobservable changes in students. The impact of water jets on milk purchases was estimated to examine a possible mechanism for weight outcomes. Findings showed a decrease in milk purchases, particularly chocolate milk, per student after water jets were adopted. Examining elementary schools and middle schools separately did not alter conclusions.

The water jets initiative is spreading across New York, aimed at promoting student health and decreasing the incidence of childhood obesity. With a one-time cost of about $1000 per machine, water jets are a relatively low-cost intervention that may reach all NYCDOE schools within a few years.

### Table 1. School Characteristics, New York City Public Schools With Students in Kindergarten Through Eighth Grade, Academic Year 2007-2008

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Boys Water Jet Schoola (n = 374)</th>
<th>Boys Non–Water Jet Schoolb (n = 482)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean zBMI</td>
<td>0.021 (0.207)</td>
<td>0.017 (0.218)</td>
<td>.83</td>
</tr>
<tr>
<td>Overweightc</td>
<td>38.9 (8.0)</td>
<td>39.2 (8.0)</td>
<td>.60</td>
</tr>
<tr>
<td>Obese</td>
<td>1.1 (6.1)</td>
<td>21.4 (6.1)</td>
<td>.59</td>
</tr>
<tr>
<td>Female</td>
<td>50.2 (4.4)</td>
<td>50.1 (4.4)</td>
<td>.64</td>
</tr>
<tr>
<td>Asian</td>
<td>12.0 (17.6)</td>
<td>14.6 (18.4)</td>
<td>.04</td>
</tr>
<tr>
<td>Black</td>
<td>36.5 (30.9)</td>
<td>33.2 (21.5)</td>
<td>.19</td>
</tr>
<tr>
<td>Hispanic</td>
<td>37.3 (26.5)</td>
<td>38.9 (27.0)</td>
<td>.38</td>
</tr>
<tr>
<td>White</td>
<td>14.2 (23.2)</td>
<td>13.3 (19.6)</td>
<td>.56</td>
</tr>
<tr>
<td>Percentage FRLd</td>
<td>85.1 (23.2)</td>
<td>87.3 (20.2)</td>
<td>.11</td>
</tr>
<tr>
<td>Percentage LEPe</td>
<td>12.1 (11.0)</td>
<td>13.5 (12.7)</td>
<td>.09</td>
</tr>
<tr>
<td>Special education</td>
<td>12.1 (5.3)</td>
<td>11.2 (4.8)</td>
<td>.01</td>
</tr>
<tr>
<td>Foreign born</td>
<td>11.3 (7.9)</td>
<td>13.3 (9.1)</td>
<td>.001</td>
</tr>
<tr>
<td>Enrollment</td>
<td>603 (323.9)</td>
<td>585 (356.9)</td>
<td>.44</td>
</tr>
</tbody>
</table>

Abbreviations: FRL, free or reduced-price lunch; LEP, limited English proficiency; zBMI, standardized body mass index (calculated as weight in kilograms divided by height in meters squared).

**“Water jet school” refers to schools that adopted a water jet prior to the end of academic year 2012-2013.**

**“Non-water jet school” refers to schools that never adopted a water jet by the end of academic year 2012-2013.** We excluded charter schools and schools that served exclusively special education students (District 75) from our sample.

### Table 2. Regression Results, Effect of Water Jets on zBMI, Overweight, and Obesity, 60 or More Cumulative School Days, Kindergarten Through Eighth-Grade Students, 2008-2013

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Boys School-Level Fixed Effects</th>
<th>Student-Level Fixed Effects</th>
<th>Girls School-Level Fixed Effects</th>
<th>Student-Level Fixed Effects</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zBMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β (95% CI)</td>
<td>-0.025 (-0.038 to -0.011)a</td>
<td>-0.017 (-0.034 to -0.001)b</td>
<td>-0.022 (-0.035 to -0.008)a</td>
<td>-0.014 (-0.031 to 0.003)</td>
<td>&lt;.001 .04 .002 .11</td>
</tr>
<tr>
<td>P value</td>
<td>.001</td>
<td>.04</td>
<td>.002</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β (95% CI)</td>
<td>-0.009 (-0.015 to -0.003)a</td>
<td>-0.012 (-0.019 to -0.005)a</td>
<td>-0.006 (-0.011 to -0.000)b</td>
<td>-0.006 (-0.013 to 0.001)b</td>
<td>.03 .01 .05 .07</td>
</tr>
<tr>
<td>P value</td>
<td>.003</td>
<td>.001</td>
<td>.05</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β (95% CI)</td>
<td>-0.005 (-0.010 to -0.001)a</td>
<td>-0.005 (-0.010 to 0.001)a</td>
<td>-0.003 (-0.007 to 0.001)</td>
<td>-0.002 (-0.007 to 0.004)</td>
<td>.02 .08 .15 .55</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: zBMI, standardized body mass index.

**Standard errors robust to clustering at the school level (P < .01).**

**Standard errors robust to clustering at the school level (P < .05).**

**Standard errors robust to clustering at the school level (P < .10).**

**Student characteristics include controls for race, eligibility for free or reduced-price lunch, English language proficiency, special education status, and age.** We excluded student observations in school years where New York FITNESSGRAM coverage was less than 50% and student observations with biologically implausible BMIs. We also excluded charter schools and schools that serve exclusively special education students (District 75) from our sample. Total sample includes 1076374 unique students.
years. Our findings suggest that the intervention is working. This study built on previous work that found that New York’s water jet intervention was associated with increased water taking among students.\(^7\) It complements the findings from a randomized clinical trial in Germany\(^6\) that found that following a school-based intervention combining increased availability of water and classroom education, the likelihood of overweight was significantly decreased. Our study adds to the evidence that school-based water interventions on their own may have positive impacts on student weight.

We included milk purchases in our analyses to explore a potential mechanism to explain the association between water jets and decreased student weight. While milk is promoted as a healthy beverage for children, and arguably has many positive nutritional qualities, it still contains calories. All chocolate milk contains sugar, both from the naturally occurring sugar lactose and from added sugar. One half-pint of fat-free chocolate milk typically contains about 20 g of sugar, about half of which is added sugar. The total amount of sugar in chocolate milk is roughly half that of other SSBs, such as a can of brown cola, which contains about 40 g of sugar.\(^24\)\(^-\)\(^26\) This study found significant decreases in fat-free chocolate milk purchases with the introduction of water jets, suggesting that milk is a reasonable mechanism for decreased BMI and overweight. A plausible explanation for our finding that chocolate milk alone decreased is that some children might not like white milk, and when given the option for chocolate choose that instead. When water is then introduced, they switch away from chocolate milk and toward water.

Another potential mechanism is that students consumed fewer SSBs brought from outside school, including sugary juice or soda. This may also explain the stronger results found for boys than girls. Work by the Centers for Disease Control and Prevention examining beverage intake among high school students found that boys consume more beverages than girls, including SSBs.\(^27\) If boys in our study consumed more SSBs, replacing those beverages with water may have yielded stronger effects for this group.

Two important data limitations are relevant. First, we used administrative data on water jet delivery and did not observe use in the cafeteria. However, water jet machines are relatively easy to use\(^7\) and no installation is required, and district personnel believe schools typically begin using water jets immediately after delivery. Second, we also used administrative data on kitchen-level milk purchases and lack data on milk consumption. Although it is likely that milk purchases are highly correlated with consumption, as the NYCDOE is motivated to eliminate waste, we did not observe consumption or waste directly. We had no data on which beverages students consume in school. According to New York vending and competitive food policies in place since the 2009-2010 academic year, elementary school and middle school vending machines only offer beverages with less than 10 cal per 8 oz.\(^12\) No district-wide policies regulate whether students are permitted to bring other beverages to school, however. Water jets were not randomly assigned, but spread across a large number of schools as part of a district initiative. Finally, we have 1 less year of milk data than water jets and BMI data. However, analyses using data for the overlap years are substantively unchanged.

### Table 3. Milk Regression Results, 3 or More Months, 2011-2013

<table>
<thead>
<tr>
<th>Outcome*</th>
<th>Year Fixed Effects</th>
<th>Year Fixed Effects and School Characteristics</th>
<th>Year Fixed Effects and School-Level Fixed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\beta) (95% CI)</td>
<td>(-12.287 (-19.371 to -5.204))</td>
<td>(-6.605 (-11.653 to -1.557))</td>
<td>(-5.153 (-8.579 to -1.728))</td>
</tr>
<tr>
<td>(P) value</td>
<td>.001</td>
<td>.010</td>
<td>.003</td>
</tr>
<tr>
<td>Mean total milk half-pints per student</td>
<td>117.554</td>
<td>117.554</td>
<td>117.554</td>
</tr>
<tr>
<td>Fat-free chocolate milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\beta) (95% CI)</td>
<td>(-13.615 (-19.796 to -7.435))</td>
<td>(-11.493 (-17.365 to -5.621))</td>
<td>(-4.705 (-8.414 to -0.996))</td>
</tr>
<tr>
<td>(P) value</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.013</td>
</tr>
<tr>
<td>Mean chocolate milk half-pints per student</td>
<td>61.602</td>
<td>61.602</td>
<td>61.602</td>
</tr>
<tr>
<td>Low-fat and skim white milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\beta) (95% CI)</td>
<td>1.375 (-4.437 to 7.186)</td>
<td>4.990 (-0.056 to 9.855)</td>
<td>-0.103 (-3.628 to 3.422)</td>
</tr>
<tr>
<td>(P) value</td>
<td>.642</td>
<td>.053</td>
<td>.954</td>
</tr>
<tr>
<td>Mean low-fat/skim milk half-pints per student</td>
<td>55.277</td>
<td>55.277</td>
<td>55.277</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year fixed-effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>School characteristics(^d)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>School-level fixed effects</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1323</td>
<td>1323</td>
<td>1323</td>
</tr>
</tbody>
</table>

*Outcomes are the number of milk half-pints per student.

\(^b\)Standard errors robust to clustering at the school level (\(P < .01\)).

\(^c\)Standard errors robust to clustering at the school level (\(P < .05\)).

\(^d\)School characteristics include controls for share of students by race, sex, eligibility for free and reduced-price lunch, special education status, English language-learner status, and total enrollment.

We included milk purchases in our analyses to explore a potential mechanism to explain the association between water jets and decreased student weight. While milk is promoted as a healthy beverage for children, and arguably has many positive nutritional qualities, it still contains calories. All chocolate milk contains sugar, both from the naturally occurring sugar lactose and from added sugar. One half-pint of fat-free chocolate milk typically contains about 20 g of sugar, about half of which is added sugar. The total amount of sugar in chocolate milk is roughly half that of other SSBs, such as a can of brown cola, which contains about 40 g of sugar.\(^24\)-\(^26\) This study found significant decreases in fat-free chocolate milk purchases with the introduction of water jets, suggesting that milk is a reasonable mechanism for decreased BMI and overweight. A plausible explanation for our finding that chocolate milk alone decreased is that some children might not like white milk, and when given the option for chocolate choose that instead. When water is then introduced, they switch away from chocolate milk and toward water.

Another potential mechanism is that students consumed fewer SSBs brought from outside school, including sugary juice or soda. This may also explain the stronger results found for boys than girls. Work by the Centers for Disease Control and Prevention examining beverage intake among high school students found that boys consume more beverages than girls, including SSBs.\(^27\) If boys in our study consumed more SSBs, replacing those beverages with water may have yielded stronger effects for this group.

Two important data limitations are relevant. First, we used administrative data on water jet delivery and did not observe use in the cafeteria. However, water jet machines are relatively easy to use\(^7\) and no installation is required, and district personnel believe schools typically begin using water jets immediately after delivery. Second, we also used administrative data on kitchen-level milk purchases and lack data on milk consumption. Although it is likely that milk purchases are highly correlated with consumption, as the NYCDOE is motivated to eliminate waste, we did not observe consumption or waste directly. We had no data on which beverages students consume in school. According to New York vending and competitive food policies in place since the 2009-2010 academic year, elementary school and middle school vending machines only offer beverages with less than 10 cal per 8 oz.\(^12\) No district-wide policies regulate whether students are permitted to bring other beverages to school, however. Water jets were not randomly assigned, but spread across a large number of schools as part of a district initiative. Finally, we have 1 less year of milk data than water jets and BMI data. However, analyses using data for the overlap years are substantively unchanged.
Conclusions

Decreasing the amount of caloric beverages consumed and simultaneouly increasing water consumption is important to promoting child health and decreasing the prevalence of childhood obesity. Moreover, schools are a natural setting for such interventions, and many policy makers are turning attention to promoting water drinking among students. Results from this study show an association between a relatively low-cost water availability intervention and decreased student weight. Additional research is needed to examine potential mechanisms for decreased student weight, including reduced milk taking, as well as assessing impacts on longer-term outcomes. Water jets could be an important part of the toolkit for obesity reduction techniques at the school setting.

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